DEVELOPMENT OF A FRAMEWORK FOR SYSTEM-LEVEL CARBON SEQUESTRATION RISK ASSESSMENT

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What is GoldSim?

- A Windows-based program for carrying out dynamic, probabilistic simulations of complex systems.

- GoldSim's origins were in long-term safety assessment of radioactive waste repositories.

- GoldSim Technology Group is a small business that focuses on developing and supporting the GoldSim software.

- Most of our clients are government agencies and consultants, over 50% international.

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How is GoldSim Used?

- Applications are very wide-ranging.
- Most applications are strategic rather than tactical
  - Ask the "big picture" questions.
- Most simulations have long time frames (e.g., years).
- Complex "total system" models.
- Many applications are high profile (high cost, high consequence).

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Primary GoldSim Applications

- ## Environmental systems modeling
  - Evaluation and remediation of hazardous waste sites, safety analysis of waste disposal sites, water resources planning and management, mine planning and management, ecosystem modeling.

- ## Engineered systems modeling
  - Reliability analysis, systems engineering, vulnerability analysis, risk and failure analysis, material handling, waste management.

- ## Business and economic modeling
  - Strategic planning, financial analysis, risk analysis and management, cost modeling, portfolio management, business process modeling.

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GoldSim Development History

- Began GoldSim development in 1998 (with DOE OCRWM support).

- Designed as general-purpose dynamic probabilistic simulation framework, with a radwaste option.

- GoldSim is used worldwide for repository performance assessment.

- It is also used in many other arenas: mining, water resources, engineering risk and reliability, insurance, health, program risk management…

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Yucca Mountain

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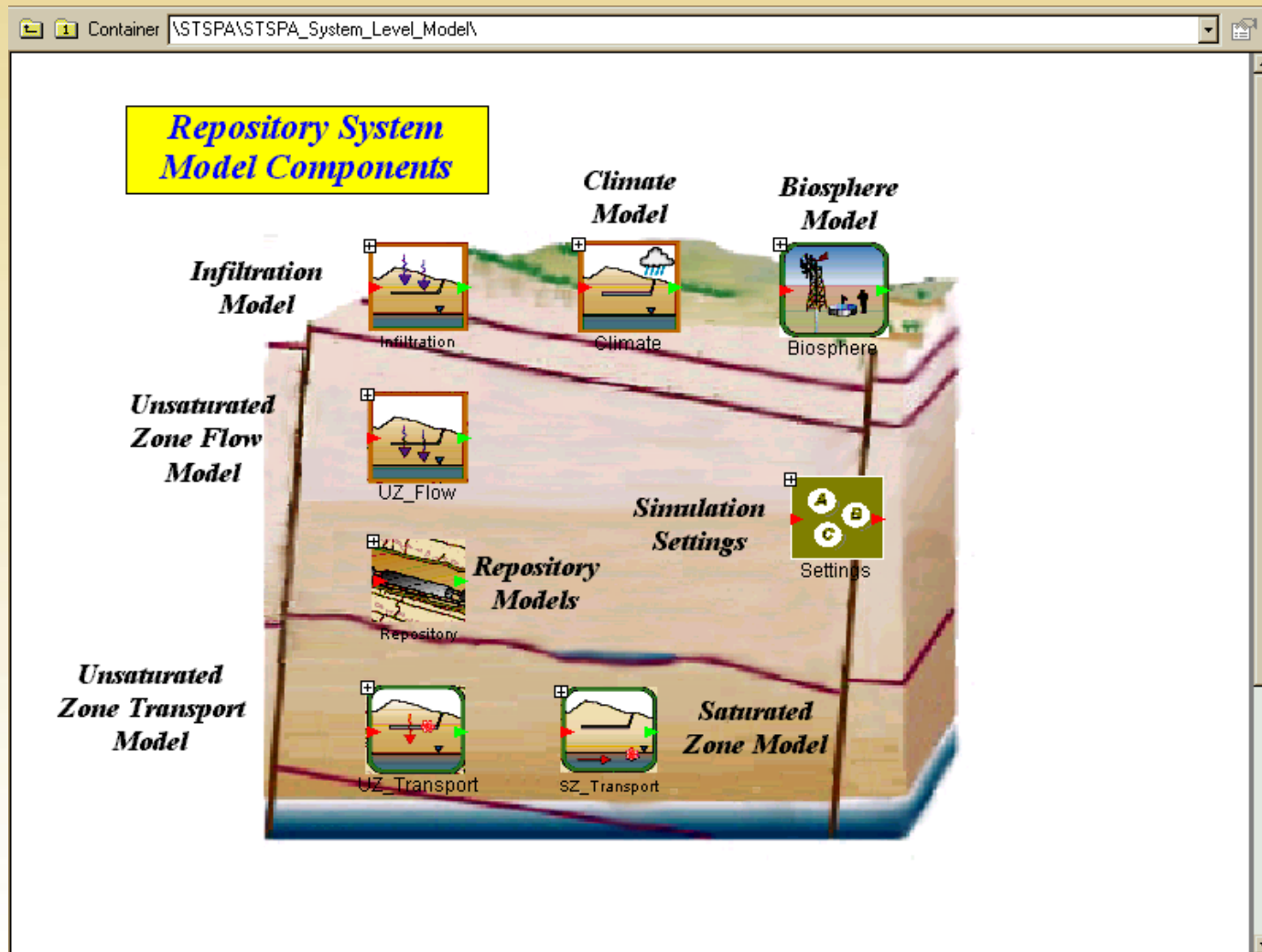
GoldSim's Philosophy

- Keep it as simple as possible; use a top-down approach.

- Concentrate on integration, coupling of processes and subsystems.

- Concentrate on incorporating uncertainty and randomness.

- Make models transparent; easy to understand and review.

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Bottom-Up Modeling Approach

- Try to build a "mega-model" in which all processes and features are treated in great detail
  - appears to be "scientifically correct".
- Limitations to solving real-world problems using such an approach:
  - Insufficient data
  - Too much uncertainty to justify complex models
  - Difficult to capture model interactions and couplings
  - Easy to lose sight of the "big picture".

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Top-Down Modeling Approach

- Concentrates on developing a consistent framework for integration of all components of the system.
- Add detail where needed, based on preliminary models.
- A properly designed top-down model is not simple.
  - Often integrate 'process models' as DLL's or response surfaces.
- The top-down approach keeps the modeling effort focused.
- Top-Down models are more transparent.
- BUT: models must be based on scientific understanding and real data!
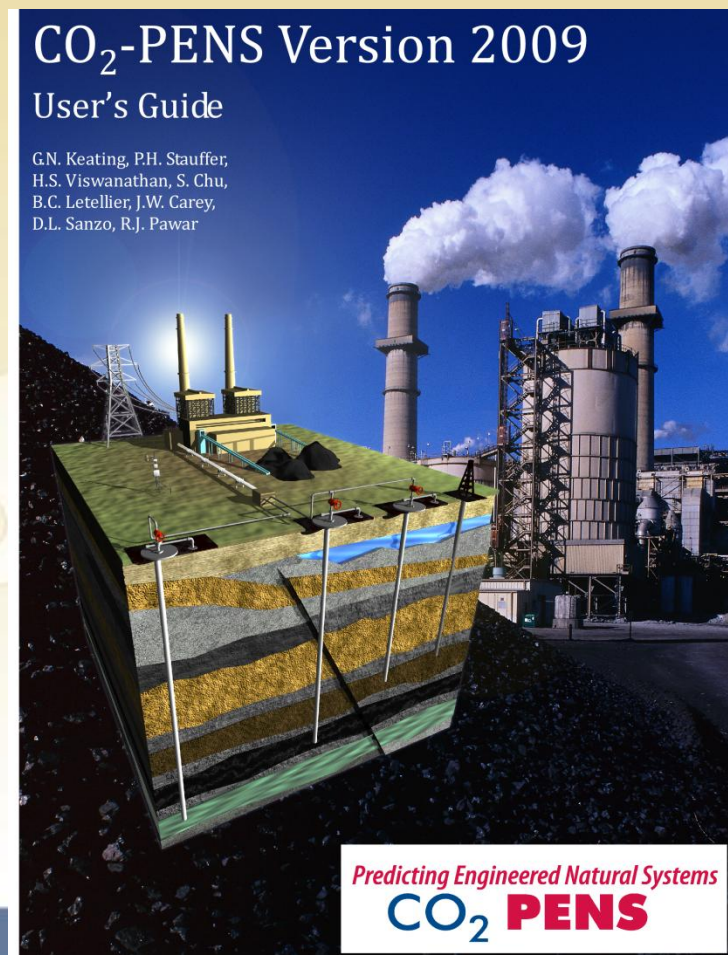
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GoldSim Features
Reflect this Philosophy

- Scalable
  - Design allows you to build a simple model, and then add details in a hierarchical manner as warranted.
- Extensible
  - Can link to other programs.
  - Designed to facilitate addition of custom modules.
- Can represent uncertainty in parameters, processes and events.
- Highly graphical and object-oriented
  - powerful navigation, presentation and documentation features allow you to build, maintain and present complex models.

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Prior Use of GoldSim for CCS Studies

- LBNL

- UK (Quintessa)

- Alberta (Golder Assoc.)

- LANL (CO_2-PENS). LANL is collaborating with us on the current project:

  - Define requirements

  - Test and validate prototypes of new capabilities.

CO_2-PENS Version 2009
User's Guide

G.N. Keating, P.H. Stauffer,
H.S. Viswanathan, S. Chu,
B.C. Letellier, J.W. Carey,
D.L. Sanzo, R.J. Pawar

Predicting Engineered Natural Systems
CO_2 PENS

Enhancement Goals

- Enhance GoldSim to be the software-of-choice for all aspects of CCS risk analysis.

- Enhance GoldSim in Four Phases:

  1. Enhanced Simulation of CO_2 Injection & Release Risks.

  2. Enhanced Comparison of Alternative Scenarios and Approaches.

  3. Enhanced Modeling of Programmatic Risk.

  4. Enhanced Modeling of Process Flows & Associated Risks.

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First Goal: Enhanced Simulation of Injection & Release Risks

- Increase GoldSim's 'number crunching' power.

- Enhanced ability to construct, simulate, and view results for complex models.

- Status: Completed kickoff meeting with LANL, Requirements Document, currently working on specific features.

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Second Goal: Enhanced Comparison of Alternative Scenarios and Approaches

- Purpose: Develop capabilities to:
  - Simulate and compare results for suites of alternatives for one base model.
  - Compare results of different (but similar) models.
- Status: About to start.

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Third Goal: Enhanced Modeling of Programmatic Risk

- Enhanced simulation of:
  - Project costs
  - Project risks (permits, financial, technical, interventions…)
  - Integration of all project risks into a single model.
- Status: Starts in 10/1010.

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Fourth Goal: Enhanced Modeling of Process Flows

- Simulate storage, processing, and transport system components.

- Develop improved capabilities to simulate equipment reliability and system impacts of potential problems.

- Integrate with injection/release risks, project risks.

- Status: Starts in 04/1011.

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Outlook:

- We're excited about what is happening in the CCS arena, and hopeful that we can make a useful contribution.

- The NETL support will allow us to enhance GoldSim to make it more directly relevant to CCS risk analysis.

- We're looking forward to meeting others working in this field.

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